Date: 17th August 2021
Our Ref No.: TJ/UT1/OUT-05

To,
Doosan Heavy Industries & Construction Co., Ltd.
Mr. Youngsoo Son– Project Manager
465 Gangnam-daero, Seocho-gu, Seoul, Korea (06611)

Contract Reference: Engineering, Procurement and Construction Contract between Nepal Water And Energy Development Company Private Limited (NWEDC) and Doosan Heavy Industries & Construction Co. Ltd for the Engineering, Procurement and Construction (EPC) for the 216 MW Hydropower Plant at Upper Trishuli -1, Nepal

Subject: Submission of Review Notes on Excavation and Initial Support Drawings of Adit No. 3 - B, Surrounding Rock Stability Calculation of Adit No. 3 - A, and Method Statement of Adit 3 Tunnel Construction – 0.

References:

1. Document No. UT1-C-000-CVL-DG-43004 (Sheet 1 to 4), Revision B dated 28st July 2021
2. Document No. UT1-C-150-CVL-DC-43002, Revision A dated 20th July 2021
3. Document No. UT1-PC-MS-019 dated 21st July 2021

Dear Sir,

Reference is made to the above Nos.1, 2 and 3, regarding excavation and initial support drawings of Adit No. 3, surrounding rock stability calculation of Adit No. 3, and method statement of Adit No. 3 tunnel construction, respectively.

Please find our comments and replies in the Review Notes (RN-0005, RN-0006, and RN-0007) enclosed herewith this letter.

Sincerely,

.....
Mr. Carsten GUNTERMANN
Project Manager (CRE)

Tractebel TRACTEBEL ENGIE Engineering GmbH

Enclosure:

1. Review Note (RN-0005), Review Note (RN-0006), Review Note (RN-0007)

UPPER TRISHULI-1 HEP (216MW)			
Client	**Nepal Water and Energy Development Company Private Limited**		
Owner's Engineer	**Tractebel Engineering GmbH / Jade Consult**		
REVIEW NOTE			
Contractor	**Doosan Heavy Industries & Construction Co., Ltd.**		
Title of the Document	Surrounding Rock Stability Calculation of Adit No. 3		
Document No.	UT1-C-150-CVL-DC-43002	Revision	A
Date of Documents	20.07.2021	Received Date	28.07.2021
Transmittal Form No.	UT1-HEP-DHI-D-0020		
Previous Review Date/Status	N/A	Prev. Review Note No.	N/A
Review Note No.	**RN-0006**	**Present Review Date**	**16.08.2021**
		Present Review Status	**RR**
A: Approved AC: Approved with Comments RR: Returned for Resubmission			

Comments

The submitted report contains fundamental errors in the assumptions of rock mass parameters and loads, which lead to entirely unrealistic results.

For example, the elasticity modulus of the modelled rock mass specified as marked refer to "intact rock" rather than to "rock mass".

Table 3.4 Rock parameters and initial supporting parameters

Item	Unit	II	IIIa	IIIb	IV
Density	g/cm3	2.7	2.65	2.65	2.6
Friction degree	degree	49	46.4	42	35
Cohesion	MPa	2.3	1.35	1	0.65
Elastic modulus	GPa	27	17	13	9
Poisson ratio		0.21	0.27	0.33	0.37
Shotcrete thickness	mm	50	80	100	100
Rock dowel length	m	N/A	3.0	3.0	3.0
Rock dowel horizontal spacing	m	N/A	2.0	2.0	1.5
Rock dowel longitudinal spacing	m	N/A	2.0	2.0	1.5

This leads to completely unrealistic results:

Table 4.1 Calculation result for Adit No.3 typical cross section

Item	Unit	Adit No.3 typical cross section			
		II	IIIa	IIIb	IV
Plastic zone max. Depth	m	1.073	0.583	0.2	0.316
Tunnel wall displacement	mm	1.28	1.31	0.42	0.65
Rock dowel stress	MPa	N/A	13.4	3.4	7.87
Safety factor of shotcrete		Satisfied	Satisfied	Satisfied	Satisfied

One recognizes that the total displacements are determined to be 1 mm for class II, which represents a rock mass of reasonable quality, and inconsistently 0.6 mm for class IV, which represents rock of bad quality.

Furthermore, stresses in the dowels were determined to be a few MPa, which is indicating that the dowels are practically not stressed. These stresses are a fraction of the steel yield stress of 330 MPa of the dowels.

The method of calculation is also wrong. Pre-deformation ahead of the face and stress reduction on the support is not considered.

These few examples lead to the conclusion that this report must be rejected without review in depth. The Contractor is therefore requested to completely revise the calculations and this document and shall consider in this process:

- Inclusion of all six rock classes.
- Reliable derivation of rock mass parameters and/or reference to existing documents where this has been done.
- Reliable modelling sequence and load assumptions for the excavation process. This means, the pre-deformation ahead of the face and of the time/location of installation of the support needs to be calculated and respective load assumptions must be demonstrated.
- Comparison of the results with the available strength of the implemented support and respective conclusions shall be drawn.

It is recommended to get familiar and follow case examples of tunnel design calculations provided in the Manual of the Calculation Program *Phase2*. The manual and design calculation examples are freely available on the internet.

For class IV and V, the designer can follow the procedure suggested by Hoek (2001) to generate acceptable results.

Reference:

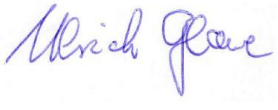
Hoek, E. (2001) Big Tunnels in Bad Rock – 2000 Terzaghi Lecture.- ASCE J. Geotech. & Geoenviron. Eng. Vol. 127, No. 9, September 2001, pp. 726-740. Freely available on the internet.

Finally, it is noted that the report submitted clearly shows that the involved design engineer(s) need to get more familiar with the design of underground structures. If the approach suggested above is implemented, soon design calculation reports can be produced that are acceptable and can be used as a guideline for the design calculations of other underground structures.

DISCLAIMER

Any approval will not release the Contractor from any of his obligations under the Contract.

Dr. Ulrich Glawe



(Signature)